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"Agrometeorology in the Meteorological Office"

by G W Hurst

Summary

A survey is given of the work and organization of the Agricultural Branch of the Meteorological Office over the last five years (1965-69). Reference is made to the scope of research and field experiments undertaken, and also to several co-operative investigations (mostly with the Ministry of Agriculture, Fisheries and Food) into major agricultural and horticultural problems. Some indication is given of future trends.

Introduction

A short account was given some time ago (Hurst[1]) of services which the Agricultural Branch gave to the agricultural community based on a colloquium on the subject in November 1964. In five years much can happen, and it is perhaps appropriate to review the present situation, particularly in relation to research projects which have been, or are being conducted.

The Branch still continues to work closely with the Ministry of Agriculture, Fisheries and Food (MAFF) in England and Wales and, in particular, with its National Agricultural Advisory Service (NAAS), which has eight Regional Headquarters including those at Bristol, Cambridge and Leeds at each of which two or three meteorological staff are based. Of the others, Reading is supported from Bracknell, and Aberystwyth, Derby, Newcastle and Wolverhampton at present rely for advice on the meteorological staff at Bristol, Cambridge or Leeds as geographically appropriate; but it is hoped that eventually agrometeorologists will be located at all eight Headquarters. The task of such a meteorologist is to advise the Regional Director, to assist in solving problems raised by his staff, and to consider the application of meteorology to agricultural and allied problems. This type of organization does not obtain in Scotland and Northern Ireland. Inquiries in Scotland are handled by specialists at the agricultural colleges, who, as necessary, consult the agrometeorologists in Edinburgh. Inquiries in Northern Ireland are dealt with by the Meteorological Office, Belfast, with some support from Edinburgh.

Close contact is also maintained, from both Bracknell and outstations, with the various agricultural research organizations - some of which come under MAFF, and some under the Agricultural Research Council (ARC), Forestry Commission, etc. - and, of course, with several university departments of agriculture and horticulture. In this context, a Senior Scientific Officer is seconded to the Grassland Research Institute at Hurley, Berkshire, for a minimum period of two years to assist in problems of meteorology and grass production. It is hoped that this will be the first of a series of secondments of this type, probably for periods longer than two years in order to allow sufficient time for the development and completion of a worthwhile programme. The strength of the Branch numbers under 20 - most of whom own gum boots!

Services

These were mentioned in the earlier review as falling into two classes: routine and non-routine. Little change in routine has taken place, e.g. weekly weather summaries are still prepared and sent to NAAS and other recipients, and warnings are still issued for potato blight and apple scab, though such warnings are increasingly being channelled through NAAS (either Regional

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Centres or the Pathology Laboratory at Harpenden). Similarly, weather information related to potential severity of liver fluke and other diseases is passed to the Central Veterinary Laboratory at Weybridge. Transpiration figures are issued for irrigation need.

Non-routine services include the answering of queries received either direct from farmers and others or, more frequently, through NAAS and similar channels. Lecture invitations unfortunately have usually to be refused because staff does not exist for the purpose, but certain commitments are accepted, such as the annual lectures to Wisley, or Kew, horticultural students, and the bi-annual symposium for the benefit of the agrometeorological observers course at the Meteorological Office Training School. In 1969, the first Voluntary Service Overseas Briefing Course was held at Reading University and the Branch participated actively in the programme. Again unfortunately it is seldom possible to spare personnel to support agricultural shows but occasionally an exhibition is mounted (see Plate I); in addition to instruments familiar to most meteorologists, this display included a wetness recorder, where dew deposited on the 'toffee apple' polystyrene knob is counterbalanced and a record is made on a barograph type of chart. These instruments are particularly used by apple and potato growers in spring and early summer.

Research over the last five years

The area covered has been very wide and an article of this length cannot cover all aspects. A representative selection is therefore discussed below, with brief indication of what has been done and of future developments, if appropriate. This is perhaps the place to mention that during the last 5 years 10 workers in the Branch published over 80 papers amongst them. (listed in Davies, 1970[4])

Foot-and-mouth disease

Following the unprecedented scale of development of the disease after the outbreak in October 1967, the Branch was consulted early in 1968 on what meteorological factors might be involved in the spread of the disease. Work was soon completed by one member of the staff on the possibility of spread from the continent; it was shown that the disease could not have so originated in 1967, though almost certainly it had in some earlier years. The main effort concerned the spread of the disease within the country, and two members of the staff worked very closely with a pathologist at the Central Veterinary Laboratory, Weybridge, and found striking relationships between the spread of the foot-and-mouth virus and the wind and rainfall during the incubation period. Thus Figure 1 shows the spread of an earlier outbreak in Hampshire in January 1967; there were seven primary sources and although from 3rd onwards the wind varied widely, the sector in which wind was associated with rain was confined to well under 180°, and subsequent outbreaks were all within this sector. Papers elaborating the results of these researches have been published in several journals.

Evidence was given by three Branch members to the Northumberland Committee of Inquiry, an outcome of which has been the creation of a scheme for putting a team (including meteorologists) on the spot without delay in future outbreaks.

Irrigation and water balance

Two particularly important events have happened; first, the new average transpiration figures were completed for the revised MAFF Technical Bulletin No. 16,[2] which was issued in 1967, and second, in 1967 MAFF published an atlas

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of long-term irrigation needs for England and Wales[3] compiled by a member of the Branch. This atlas indicates the irrigation required over varying periods of the summer half of the year to ensure that various planned soil moisture deficits (SMDs) are not exceeded, considering the needs of the driest year in 20 and also those of the 5th driest year in 20. Figure 2, based on a plate from this atlas, shows the irrigation required in the 5th driest year in 20 to restore the ground to field capacity every time a 2-inch SMD is reached in the 4-month period May to August.

Work continued on rainfall effects on agriculture and included studies, principally through SMD considerations, of excess rainfall in autumn and winter, with consequent leaching and poaching problems, and of return to field capacity in autumn with subsequent flooding, etc.

Work being done on machinery 'work days' is related to water-balance considerations; very broadly the approach is to assess the wet days in spring and the water balance in autumn.

Cropping and meteorological factors

Some work has already been done relating cropping to current and preceding weather and this continues to be an important and active field of research. An approach has been made to consider effective transpiration, defined as the calculated actual transpiration occurring when the SMD is less than 2 inches in the root zone, and in particular the problem of effective transpiration and the growth of grass has been studied. Some work has been done on the harvesting and quality of crops such as hops, wheat and barley; with hop yields for example, the main meteorological variables considered are effective transpiration in spring and early summer and sunshine in late summer and the beginning of autumn. Work is being done relating hop quality to meteorological factors, especially temperature, for a period before harvesting; Plate II shows maximum and minimum thermometers in cocoa tin mounts in hop-field trials in Kent. A study is just starting to help to assess the suitability of the climate in southern England for maize production.

An important application of the research on grass growth has led to good forecasts being made in March and June of the probable milk yields up to the following spring. The most important meteorological factors are the soil temperature excess above 43°F (in March) and the effect of June rainfall on subsequent hay quality - dry weather at this stage goes with good quality hay. Figure 3 shows well the accuracy of the forecast of annual milk yields made at the end of June for the year ending in the following March; a regression equation includes factors for the milk yield in the preceding months April to June, and a term for the June rainfall.

Also related to quantity and quality of crops is the study of honey production and meteorology. No short-term forecast technique has been found here as the main weather relation is between high honey yields and hot weather in July (especially) and August, but examination of temperatures over the last century suggests that future prospects for better honey yields are far from rosy.

An approach has also been made to evaluate crop potential by forecasting the level of a particular disease or pest. Thus high February temperatures lead to a high level of yellows virus disease in sugar-beet. Rather similarly,

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consideration was given to the activity of the shallot aphid, which can be very damaging to strawberry crops; again, high February temperatures are associated with high pest incidence.

Animal diseases

Working closely in conjunction with a very energetic and interested pathologist at the Central Veterinary Laboratory, a member of the Branch has found that the incidence of several diseases of sheep and cattle is closely related to meteorological factors, e.g. liver fluke in sheep to summer rainfall. Examples include pregnancy toxaemia of ewes, the incidence of which was found to be higher in cold wet winters; a numerical relationship with weather was established for this as for the other diseases. Nematodirus of sheep was found to be closely related to the 1-foot earth temperature, and the hatching out of the larvae was related to March temperatures, high temperatures being associated with an early hatch. A useful preliminary forecast was possible in the second half of March. Gastro-enteritis of cattle is associated with late summer or early autumn rainfall and this, with knowledge of the previous year's disease figures, enables a fairly accurate assessment of the following year's disease level to be made.

Other diseases were investigated, such as swayback of ewes and stillbirth in autumn calvers.

Airborne movement

Much has been done in the examination of movements of insects, spores, viruses, pollens, pollutants, etc; reference has already been made to the movement of foot-and-mouth virus. Many analyses have been made using synoptic charts (usually in collaboration with entomologists from Rothamsted Experimental Station, Harpenden, or elsewhere), for example analyses of particular flights across the Atlantic, and definite patterns of immigration have been established for some species of insects. In this connection, a monthly analysis of trajectories to Great Britain from the continent has been prepared from 1946 onwards using a weather classification approach. Analysis has been made and published of spore trapping over the North Sea and elsewhere by the Meteorological Research Flight in conjunction with Rothamsted. This has shown very interesting patterns of spore and pollen concentrations in relation to the diurnal temperature over the source area (UK usually), often with marked maximum counts well away from the English coast; vertical changes were considered in relation to stability and terminal velocities. The impactor trap, as used on a Hastings aircraft of the Meteorological Research Flight, and the sampling head are shown on Plate III. Diffusive processes have also been studied both with the spread of potato blight, fireblight, etc. and (using radioactive tracers) with indoor, controlled movement in animal houses; movement in vegetable stores has also been examined. It has been possible to point out completely wrong design of ventilation systems on at least one occasion.

Field experiments

The Branch has participated in several important field trials and is still doing so. Three of interest are those in Thetford Chase, the orchard trials and the watercress trials. The Thetford experiments were made in conjunction with the Forestry Commission and were concerned with frost damage to young and sensitive Corsican pine saplings. A network of minimum thermometers exposed in 'cocoa tins' was maintained for three years with modifications in the light of experience; results are proving very helpful to the Forestry Commission.

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The orchard trials were started at the request of NAAS to investigate the weather effects on orchard performance in different parts of southern England and the west Midlands; the experiments were conducted over three years, and preliminary survey of results seems to confirm the meteorologists' expectations that macroscale differences are important, but that mesoscale differences seem to matter much less than factors such as pollination and husbandry. The watercress trials, started late in 1969, also in conjunction with NAAS, are expected to continue for several winters. Seventeen similar parallel concrete beds have been laid down at a cress farm and temperatures are being measured for different water flow rates and for other varying régimes; very interesting results are hoped for, linking varied flow rates, cover and crops with fall of temperature as the (well) water proceeds down the beds. The general layout of the site at Fobdown, Hampshire, is shown in Plates IV (a) and (b). Plate IV(a) shows the whole site of 17 beds and Plate IV(b) shows a single bed with cress growing and a framework for the polythene cover; probes for mercury-in-steel thermographs are located about 2 feet from the ends of several of the beds.

Land use

Work under this heading mostly does not fall under the title of research, apart from certain aspects such as the effect of slope on classification of land grading and the shelter effect of land forms and topographical factors generally. A classification is being done by the Agricultural Land Services with which the Branch co-operates; it is mainly a map exercise with occasional support by field examination. Eventually the whole of England and Wales will be covered, using as the basic map the Ordnance Survey 1 inch to 1 mile.

Work in much more detail is also being done in certain areas for a horticultural survey of land potential.

Miscellaneous

Valuable work continues in various directions, but in a short space, passing mention only can be made of a selection as follow: the relationship of mulching with soil temperatures; the effect of shelter, both natural and artificial; meteorological problems in upland climates, including continued interest in flag tattering as a measure of wind flow. The Branch continues to be represented on the Shelter Research Committee. Important pioneering work is also being done on radiation levels within glasshouses, and a computer programme is being developed for the assessment of glasshouse design and location.

International services

Finally a little must be said of the contribution of the Meteorological Office outside the realms of domestic agriculture and horticulture. Considering first the World Meteorological Organization (WMO) the Branch contribution is distinguished; in addition to providing the President of the Commission for Agricultural Meteorology since 1962 it has provided chairmen for two Working Groups and five rapporteurs on various subjects. Six WMO Technical Notes written within the Branch are either already published or well under way.

The Branch has been well represented at conferences. In the five years covered, one or more members have attended at least 12 conferences or meetings overseas and many more in this country, and at most of the conferences, leading papers were presented and sessions and working groups were chaired. Pressure

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of work and other reasons have necessitated refusal of some quite pressing invitations from abroad.

In 1970, plans are in hand for representation at a symposium on 'Plant Responses to Climatic Factors' in Uppsala (Sweden); it is expected that a three-month visit to Turkey will be made by a member of the Branch in autumn to complete a six-month period of technical assistance in agrometeorology which started in 1967. It is hoped that in November a Branch member will conduct a WMO seminar in Barbados on agrometeorology.

References

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2. London, Ministry of Agriculture, Fisheries and Food. Potential transpiration. Tech. Bull. Minist. Agric. Fish, Fd, London, No. 16, 1967.

3. HOGG, W H — Atlas of long-term irrigation needs for England and Wales. London, Ministry of Agriculture, Fisheries and Food, NAAS, 1967.

4. DAVIES, D — Agricultural Memorandum No. 325. Bibliography of recent papers.

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Bracknell, Berks.
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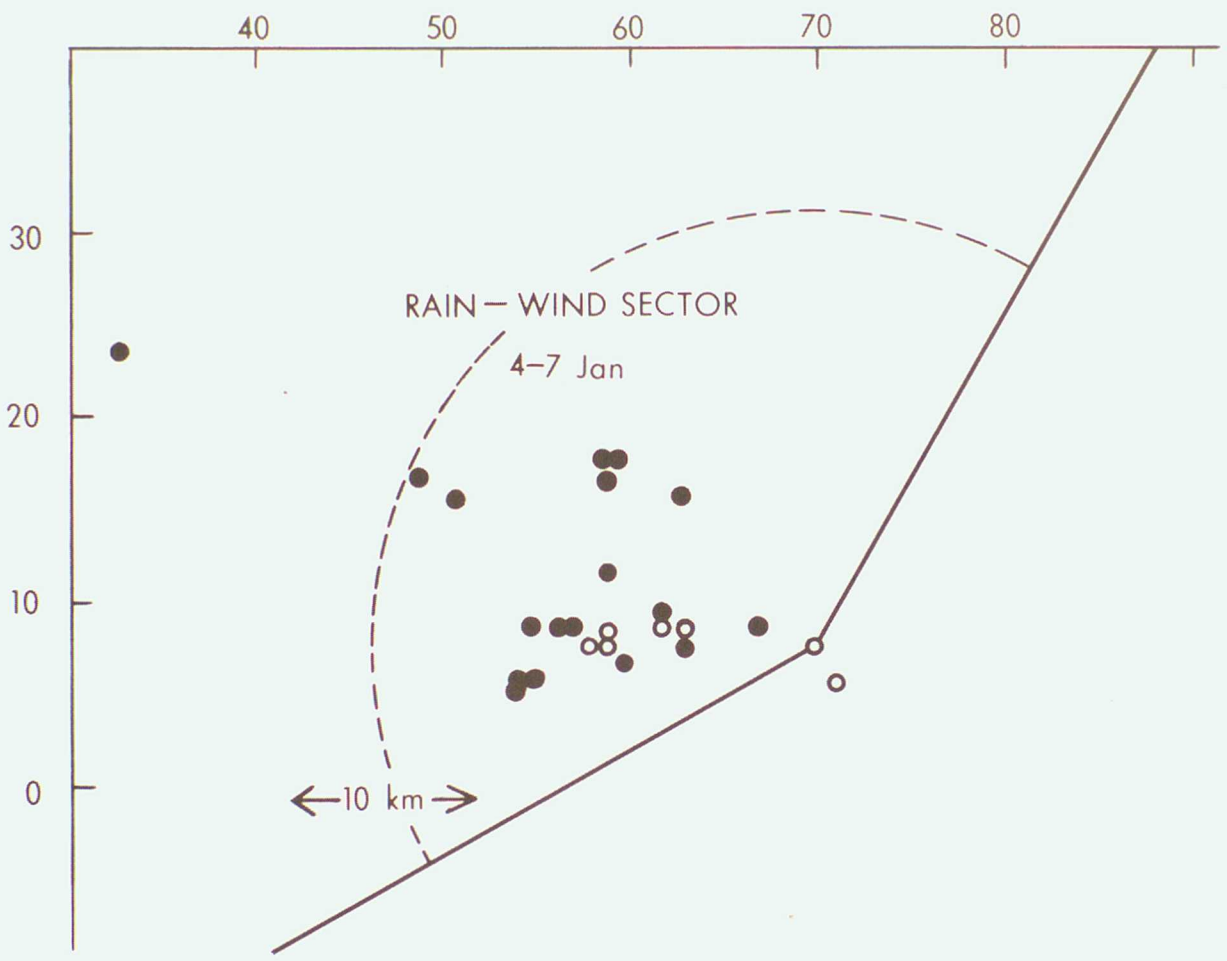


FIGURE 1—SPREAD OF FOOT-AND-MOUTH DISEASE IN HAMPSHIRE IN JANUARY 1967

○ Sources ● Infections from 8–22 January

Figures on axes are National Grid references.

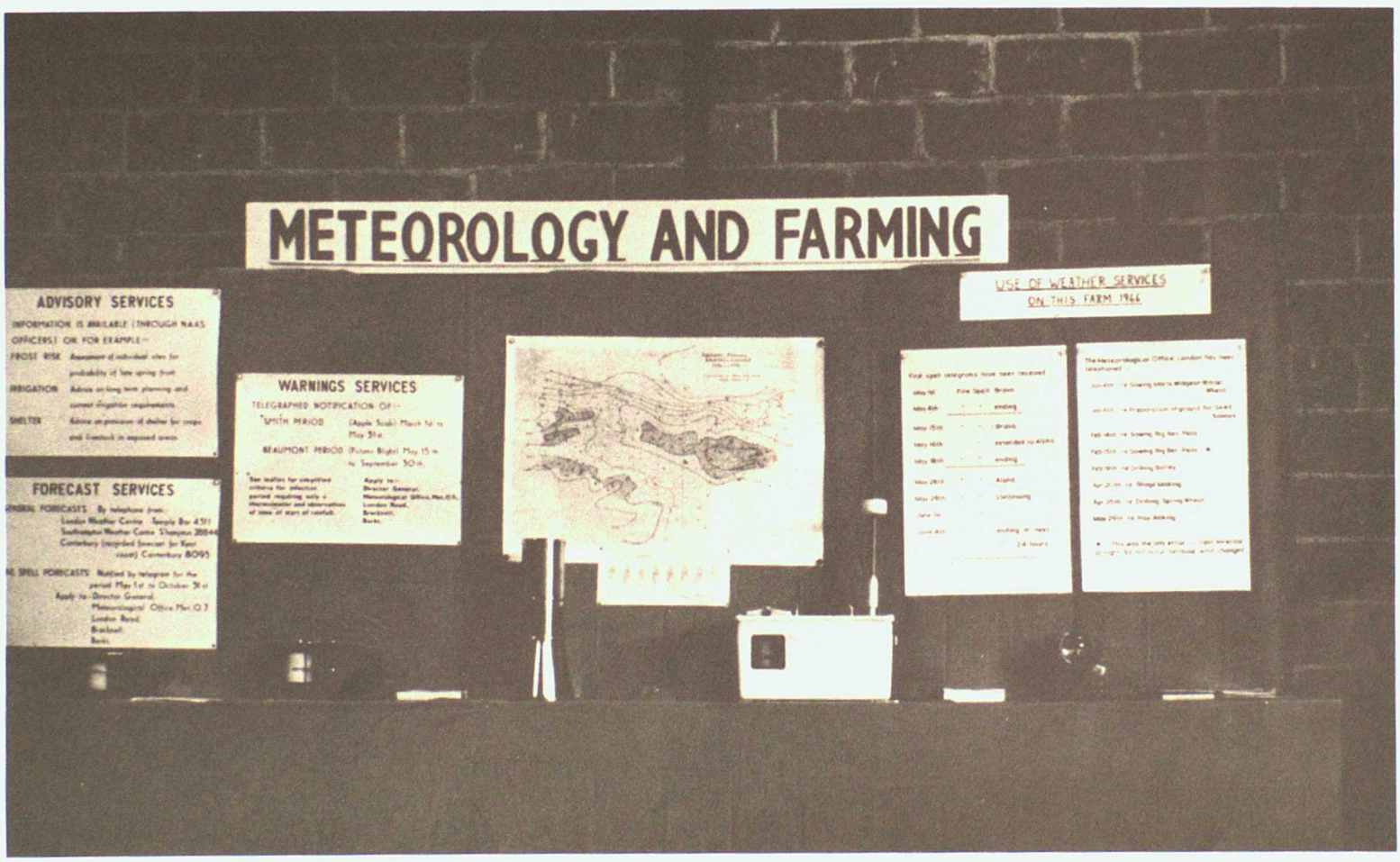


PLATE I—METEOROLOGY AND FARMING EXHIBITION

Photograph by J. Cochrane

The wetness recorder is just right of centre. See page 171.

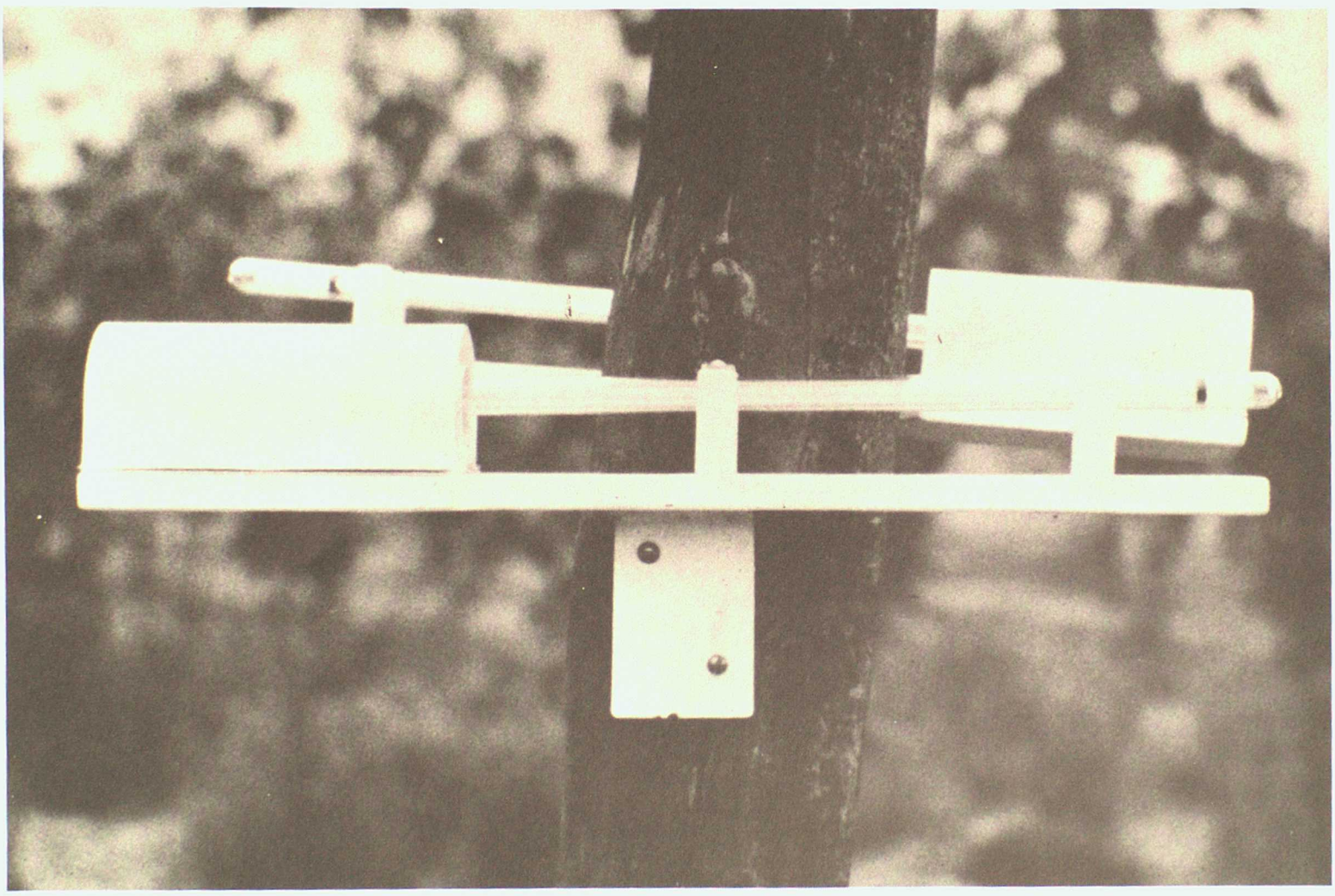


PLATE II—MAXIMUM AND MINIMUM THERMOMETERS IN TWO COCOA-TIN MOUNTS IN HOP-FIELD TRIALS IN KENT

PLATE III*(a)*—IMPACTOR USED FOR SPORE COLLECTION BY AIRCRAFT

The right half of the instrument projects horizontally out of the aircraft, perpendicular to the side, in free airflow.

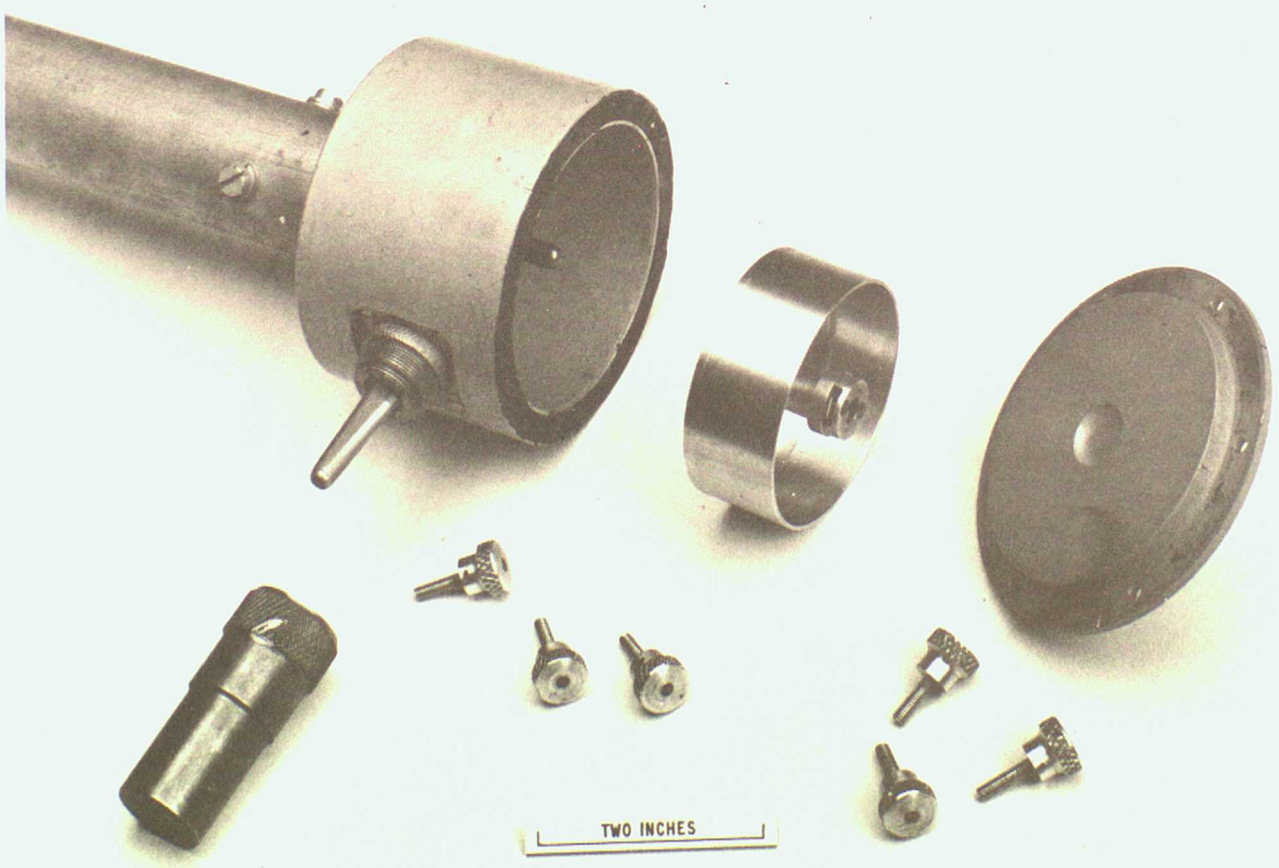
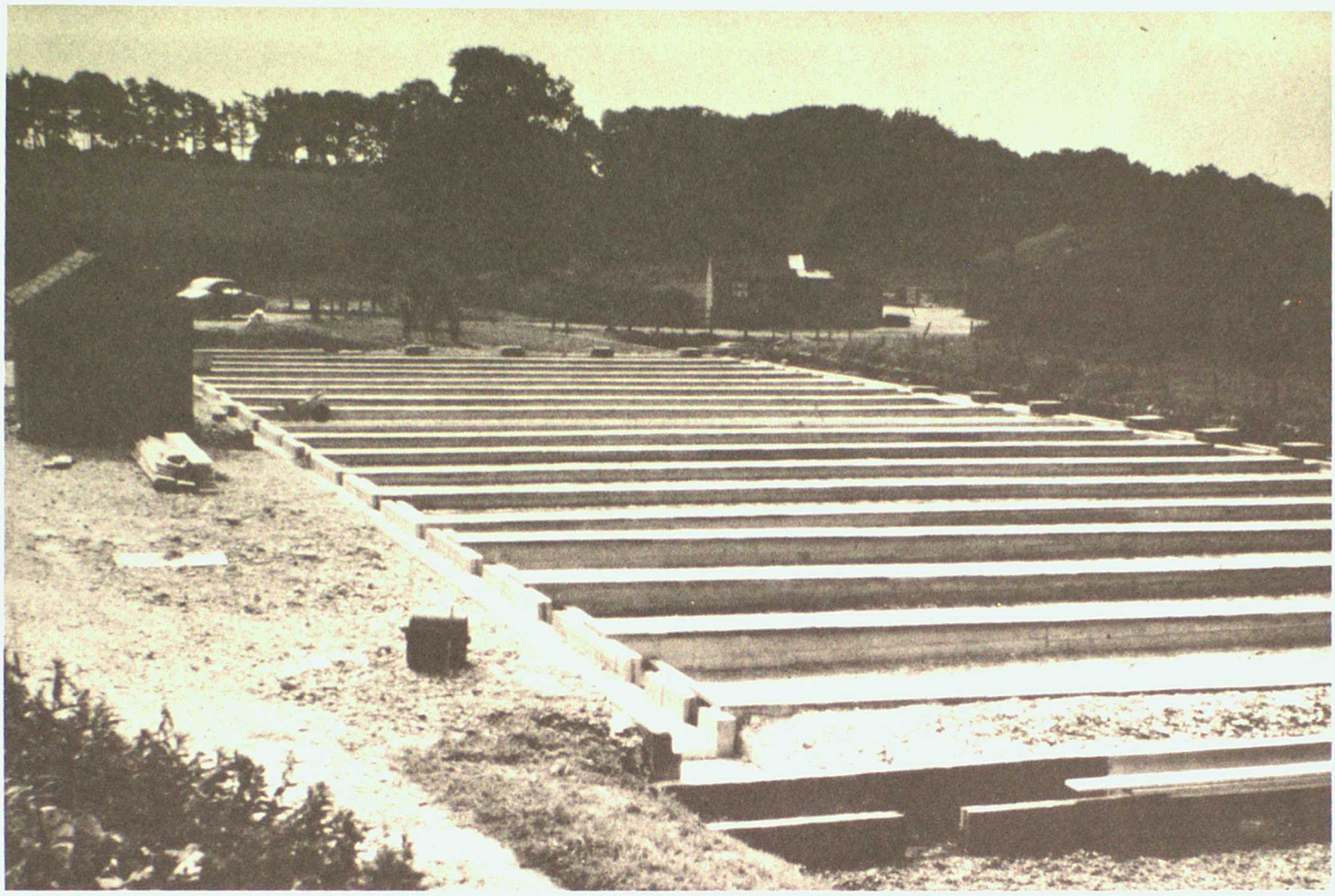


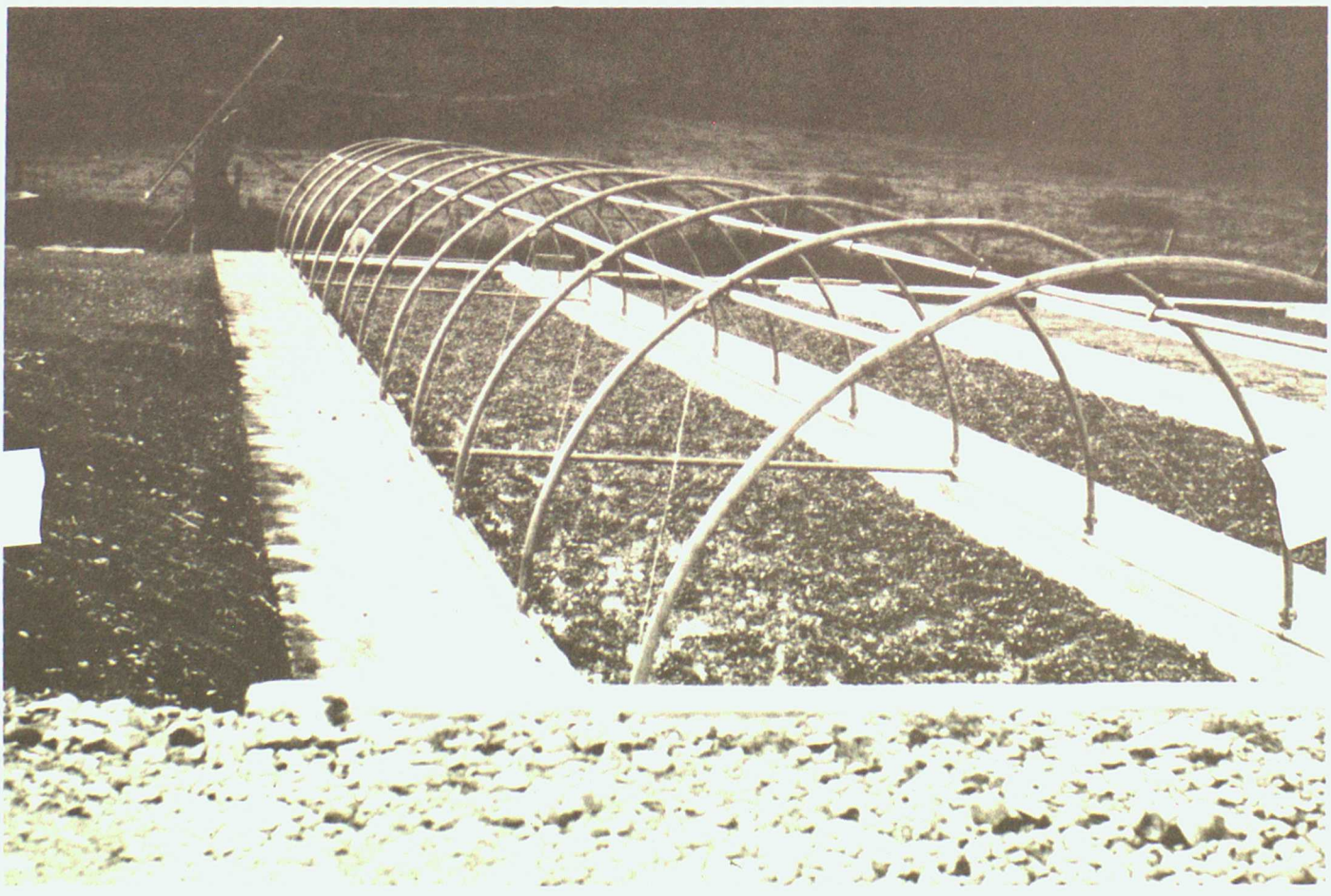
PLATE III*(b)*—SAMPLING HEAD OF IMPACTOR

The orifice on the side of the head is protected by a cover (lower left) before operation. Spores are impacted on sticky transparent tape wrapped round the drum (centre).

Photographs by courtesy of Royal Aircraft Establishment, Farnborough



(a) Whole site of 17 beds.



(b) Single bed showing framework for polythene cover.

PLATE IV—WATERCRESS BEDS AT FOBDOWN, HAMPSHIRE

Photographs by J. Cochrane

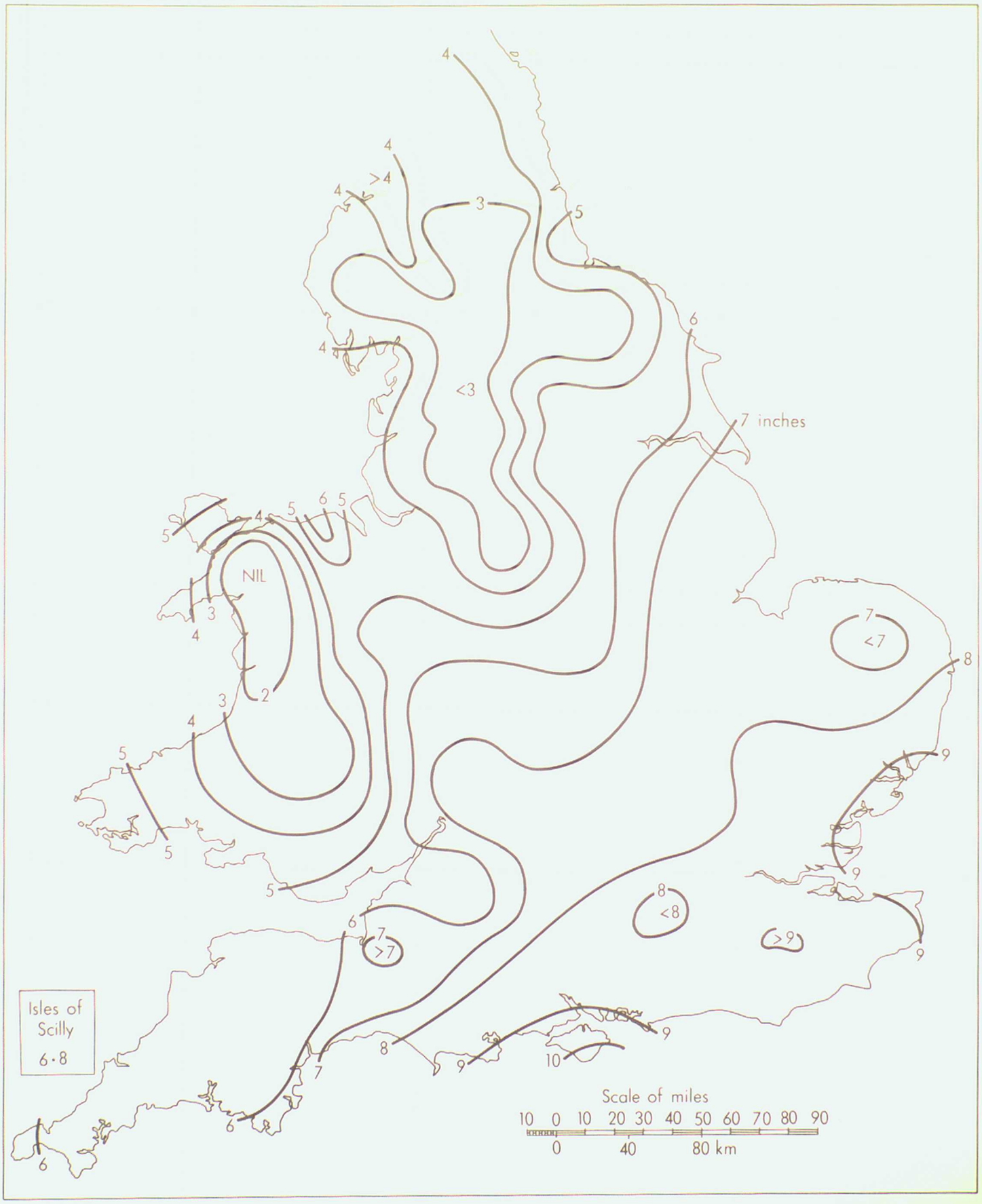


FIGURE 2 IRRIGATION NEED IN 5th DRIEST YEAR IN 20 FOR THE PERIOD MAY TO AUGUST (after Hogg[3])

Shows irrigation required to restore the ground to field capacity whenever a 2—inch soil moisture deficit is reached.

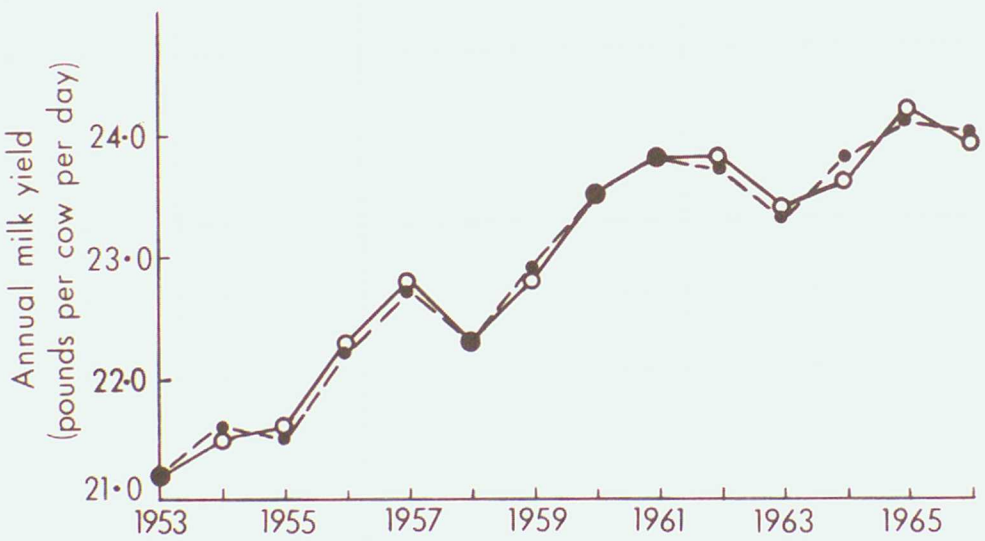


FIGURE 3—FORECASTS OF ANNUAL MILK YIELDS, MADE AT THE END OF JUNE FOR THE YEAR ENDING THE FOLLOWING MARCH

o——o Actual ●– – –● Forecast

Mean percentage error 0 31.